

## 3.8.2 Carotid Artery Distensibility

### Sonographer Manual

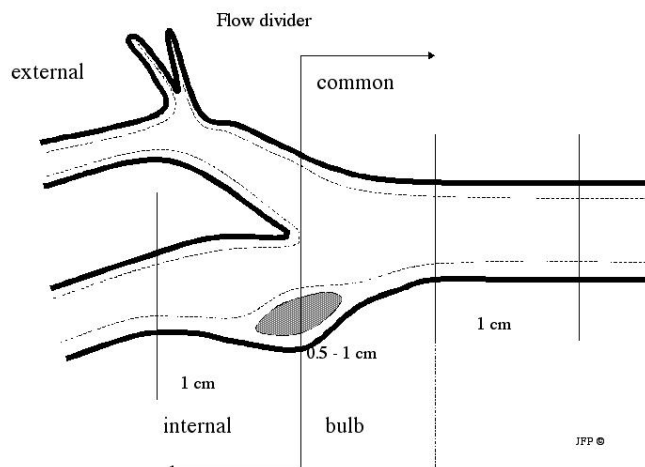
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#### I. OVERVIEW OF THE CAROTID ARTERY DISTENSIBILITY (STIFFNESS) SCANNING PROTOCOL

Changes in arterial stiffness are associated with hypertension and atherosclerotic changes in the arterial wall. Measurement of the change in diameter of the carotid artery can be combined with blood pressure measurements to give an index of arterial distensibility (inverse of stiffness). Although blood pressure should ideally be measured in the arterial segment being studied, brachial artery pressures have been used as a substitute. An important variable affecting arterial stiffness is the thickness of the artery wall (IMT: intima-media thickness). Distensibility of an artery segment is a reflection of the mechanical stress affecting the arterial wall during the cardiac cycle.

A comprehensive evaluation of distensibility of an arterial segment should include accurate measurements of the artery diameter, the thickness of its' wall as well as local blood pressure (or an acceptable substitute).

#### II. INTRODUCTION TO THE CAROTID ARTERY DISTENSIBILITY SCANNING PROTOCOL



The common carotid artery (CCA) dilates to form the carotid bulb proximal to the bifurcation into the internal and external carotid arteries. The origin of the bulb can be recognized in most, though not all, subjects. The common carotid artery bulb is defined as the site where the artery begins to dilate slightly and the vessel walls curve out, i.e.: they are no longer parallel to each other. The bulb is elliptically

shaped and geometrically complex in the longitudinal view. The tip of the flow divider defines the bulb's upper limit. The tip of the flow divider also marks the origin of the internal and external carotid arteries.

Evaluation of the common carotid artery stiffness is made on a segment at least 1 cm before the carotid bulb. The common carotid artery is, at this level, an elastic artery. Although distensibility requires a simultaneous measurement of common carotid artery pressures, such a measurement is not possible given the constraints of the current imaging protocol. Blood pressure measurements will be made in both arms to verify that there are no significant gradients. The highest of the two pressures will then be used for subsequent measurements and will be repeated once more after recording the right common carotid images.

Ideally, the average of the two systolic and diastolic pressures in the left arm will be used for further calculations of stiffness values. In cases where the right arm pressure is significantly greater (15 mmHg or more) than the blood pressure measured in the left arm, a repeat measurement will be obtained from the right arm and averaged with the other right arm measurement.

### III. PROCEDURES

#### 1. Participant and blood pressure cuff positioning

- 1.1 The subject is supine during the carotid artery examination and is made comfortable in a position that allows head rotation to either side. The sonographer stands or is seated at the end of the exam table near the participant's head. The top of the head is about three inches from the end of the examination table and the head is rotated 45 degrees to the left. Participants may wish to turn their heads to look at the screen. This should be discouraged. The sonographer may gently place his/her hands on the subject's head as an aid to rotate the head in the correct position. The sonographer should emphasize the importance of not moving.
- 1.2 A blood pressure cuff is connected to an automated sphygmomanometer (Dinamap®) placed over the right and left upper arm. Blood pressures are recorded from the left and right arms. The arms are held slightly abducted from the body.
- 1.3 For MESA, a blood pressure cuff placed around the left arm is used to measure systolic and diastolic blood pressures.

#### 2. Distensibility blood pressure summary

- 2.1 Depending on the order the ultrasound protocols are conducted in MESA some blood pressures can be eliminated.

Time in Protocol	MESA Protocol if Distensibility follows Brachial Artery Endothelial Function	MESA protocol if Distensibility study is done at a separate session from the Brachial study
1. Baseline	Left and right arm obtained during the	Left arm

2. Baseline	Endothelial Function scan	Right arm
3. Post Imaging	Obtained from left arm	Left arm repeated unless the right systolic pressure is 15 mm HG or more higher

2.2 When the Brachial Artery Endothelial Function scan immediately precedes the Carotid Artery Distensibility scan, use the blood pressures obtained during the Brachial Artery Endothelial Function scan as the Carotid Artery Distensibility baseline blood pressure. Transcribe the “Endothelial Function” Item 16 systolic and diastolic blood pressures to Item 3 of the “Ultrasound Distensibility case report form. In summary, when the Brachial Artery Endothelial Function scan immediately precedes Carotid Distensibility, only one set of systolic and diastolic pressure measurements are taken. This measurement is done after the acquisition of the distensibility images.

2.3 When the Brachial Artery Endothelial Function scan does not precede the Carotid Artery Distensibility study, baseline bilateral blood pressure measurements and a post imaging baseline blood pressure are taken and recorded on the MESA Ultrasound Distensibility case report form.

### 3. Anatomical site of interest - distal common carotid artery

3.1 The common carotid artery segment ends at the tip of the flow divider, which is typically the most clearly defined anatomical reference in the carotid system. Adjacent to this segment is the carotid bulb, a zone where the walls of the common carotid artery diverge from parallel lines. The segment of interest is the distal common carotid artery at least 1 cm below the carotid bulb.

#### 3.2 Anatomical definitions

- *Distal common carotid* is the segment of the common carotid artery immediately proximal to the origin of the carotid bulb, where the near and far walls of the artery are parallel to one another. The end of the distal common carotid artery is marked by the dilatation of the vessel walls, which is the carotid bulb.
- *Carotid bulb*: the inferior extent of the bulb is the beginning of dilatation or at least 8 mm below the tip of the flow divider. The superior extent of the bulb is defined by the very tip of the flow divider.
- *Internal jugular vein* lies superficial and somewhat lateral to the common carotid artery. It serves as the imaging window for acquisition of the distensibility measurements

### 4. Initial Scan (Videotaped for 10 seconds at a 4 cm field-of-view)

- 4.1 All images are taken only from the right common carotid artery with the Common Carotid Presets entered in the GE Logiq 700 device.

Frequency: 13 MHz  
66 Dyn Range  
Res  
Edge 3  
Map G  
Ave. 2  
Number focal zones: 2  
Position of focal zones: mid artery

- 4.2 The participant ID number is entered

Press "New patient"  
Hit "return" until you reach the new patient question (Y/N); type "Y" and then return  
Keep hitting return until the Last Name field: Type "right cca"  
Keep hitting return until the ID# field: enter the ID number  
Hit return for gender (M or F)  
Hit return and enter your ID  
Hit the "Exit" key to exit

- 4.3 The purpose of the initial scan is to orient the sonographer to the subject's carotid anatomy:

- To identify the relative location of the jugular vein to the common carotid artery,
- To locate the bifurcation and;
- To locate the common carotid artery bulb.

- 4.4 Videotape is on.

This initial scan is done in the plane transverse to the artery and vein. The transducer is slowly swept from the low common carotid artery (just above the clavicle) to just above the origins of the internal and external carotid arteries: the transducer is kept over the internal jugular vein so that the vein is stacked on top of the artery. Once the location of the bifurcation is identified, the transducer is slowly rotated to a plane parallel to the axis of the artery and vein. The jugular vein then serves as an acoustic window for imaging of the common carotid artery. Apply only a minimal amount of pressure to the transducer in order to prevent collapse of the vein and loss of the acoustic window.

- 4.5 Videotape is off.

## 5. Standard carotid artery distensibility ultrasound images

All images are taken only from the right common carotid artery. Summary of imaging sequences:

- A pulse-wave Doppler tracing is recorded over at least 5 cardiac cycles, approximately 5 seconds of *real-time* imaging. (**Video Sequence 1**)
- Videotape the optimal "zoomed" image of the common carotid artery. Both near and far wall interfaces defining the intima-media thickness should be clearly imaged over a 1 cm length. This recording is made for 20 seconds (approximately 20 cardiac cycles) (**Video Sequence 2**)

### 5.1 Video sequence 1 - pulse-wave Doppler



A 4 cm field-of-view is used as the default image size.

The critical information is the peak-velocity in the common carotid artery at peak systole at the point of maximum flow acceleration. A 2-mm Doppler sample gate is placed in the center of the distal common carotid artery. The audible signal can be used to facilitate placement of the Doppler sample gate. Angle correction should not exceed 60 degrees. The real time Doppler tracing is videotaped for approximately 5 to 10 seconds. The image is then frozen and videotaped for another 5 seconds.

- Hit the "cursor" key.

- Move the cursor to the middle of the artery with the trackball
- Press the toggle switches ("angle steer" and "angle correct") until there is an angle of 60 degrees or less between artery axis and the ultrasound beam.
- Press the PW button. Adjust the velocity scale so that the Doppler waveform fits the display (Y-axis).
- Turn the videotape on for 5 -10 seconds until a satisfactory Doppler tracing is obtained
- Freeze the image and let the videotape record the frozen image for 5 seconds
- N.B. The velocity scale is set so the Doppler waveform fills the display.

## 5.2 Video sequence 2 - right common carotid real-time gray scale imaging

Imaging is done in the lateral projection with the jugular vein lying immediately above the common carotid artery (or at 45 degrees if the internal jugular vein is not present). The image is centered on a 10 mm segment of the right common carotid artery at least 10-mm below (caudad to) the right common carotid artery bulb. The carotid bulb may be displayed on the left side of the monitor (when facing the screen). If the bulb cannot be identified, but the tip of the flow divider can, this may substitute as the internal landmark on this view.



After locating the tip of the flow divider on the transverse image, the transducer is slowly moved down the neck approximately 2 to 3 cm. Rotate the transducer into the lateral plane keeping the jugular vein in the same imaging plane. The probe is then centered on the upper 2 cm of the common carotid.

The sonographer magnifies the longitudinal image (jugular vein above common carotid artery).

- Press the "ZOOM" button
- Use the trackball to center the distal common carotid artery (edge of bulb occupying less than 1/3 of the image to the left hand side of the screen)
- Press the "SET" button
- Videotape a minimum of 20 seconds so that the images in the video sequence are from at least 20 cardiac cycles. The common carotid artery wall interfaces (near and far wall IMT interfaces) are clearly depicted during this recording.

#### 6. Sonographer response to a significant stenosis – ALERT

- 6.1 Some participants will have significant carotid stenoses, which are discovered, perhaps for the first time, during this examination. An ALERT is defined as an 70% or greater stenosis in the common carotid, the bulb or internal carotid artery. The only criteria used to estimate stenosis is the peak systolic pulse-wave Doppler. A 70% or greater stenosis is indicated by a pulse-wave Doppler measurement of 250 cm/s. Imaging data should **not** be used in arriving at this conclusion; its role is limited to determining the site of the abnormality.
- 6.2 If a sonographer believes a significant vascular abnormality is present, he should double-check this finding by repeating the Doppler measurement. Under no circumstances should the impression of a problem be conveyed either directly or indirectly to the participant by the sonographer. **The clinic coordinator should be told immediately after the participant has left the scanning area.** An inquiry is thereby triggered at the field center regarding the presence of relevant symptoms in the participant. It will be determined whether he is under care for the vascular abnormality and if necessary appropriate referrals will be provided
- 6.2 The responsibility of the participant's health care is completely with the field center. Whenever a participant presents with what the sonographer suspects is a problem he is to communicate it immediately to the field center medical personnel. **Do not wait for confirmation from the Ultrasound Reading Center.** The scan will not be reviewed until at least

a week later. The readers and the project manager are not qualified to provide any sort of diagnostic report.

## 7. Sonographer Response to High Blood Pressure - ALERT

**The sonographer is to report blood pressure alerts to the clinic coordinator immediately without indicating a concern to the participant.**

### 7.1 Alert levels requiring immediate referral for MESA patients are:

Immediate: Systolic > 200 mmHg or Diastolic > 120 mmHg

### 7.2 Alert levels requiring referral within one week are:

Urgent: Systolic > 180 mmHg or Diastolic > 110 mmHg

## 8. Protocol summary

### 8.1 Initial blood pressure measurements

- Left Arm
- Right Arm

8.11 If right arm systolic pressure is 15 mm HG or more higher than left arm systolic pressure, measure the right arm blood pressure at the end of the session.

8.12 If the MESA Brachial Artery Endothelial Function scan immediately precedes the Carotid Distensibility scan, use the last blood pressure Brachial Artery Endothelial Function blood pressure as the Carotid Distensibility pressure.

### 8.2 Imaging – videotape the following images, in this order:

8.21 Doppler Imaging with a clear Doppler waveform from the common carotid artery: real-time 5 to 10 seconds with display of a frozen image for 5 seconds (at 4 cm field-of-view)

**NOTE: A Doppler value greater than 250 cm/s is an ALERT—  
Tell the clinic coordinator immediately!**

8.22 Twenty (20) seconds of (ZOOMED) *real time* images of the common carotid with the jugular vein being used as an acoustic window.

### 8.3 Post-imaging blood pressure



Left Arm (right arm if right arm pressure is 15 mm Hg or more than the left arm)